

curved sharply (fig. 9 a). In *Buccinum*, as just stated, the dorsal border terminates in a straight point. Although this trait is only a microscopic incident of formation, it is quite enough to constitute the distinctness of the species. In every other respect the laminæ discover the same structure as that just explained in *Buccinum*. The gill-leaves of *Murex* and *Nassa* exhibit also slight variations of *shape*, compared with the standard figure of those of *Buccinum*. From such examples the naturalist may well exclaim, how marvellous and unaccountable, that in establishing the independence of species, Nature should change the very fabric of the minutest parts of the body!

In the Conidæ and Cypræadæ, the author has every reason to believe that the branchiæ conform with exactness to the type of those of *Buccinum*. They may vary in the special outline of the laminæ, but not in essential structure. They lie in the branchial chamber in the same oblique position, and exhibit the same relation to the glands of the cavity.

Although the transition may be strange and abrupt, it is convenient at this point to pass to the consideration of the pulmoniferous Gasteropods; not because there is much in common between their breathing system and that of the branchiferous orders, but because the glands contained in the thoracic cavity of the Pulmonata correspond in structure and dependencies most intimately with those which are contained in the branchial chamber of the Pectinibranchs last described. According to this distribution of subject, the "glands" of the respiratory cavity of both the branchiferous and pulmoniferous orders will come to be considered under one head.

[To be continued.]

V.—On the Origin of the Geographical Distribution of Crustacea.
By Mr. JAMES D. DANA.

[The present paper is the conclusion of Mr. Dana's Report on the Geographical Distribution of the Crustacea. As the opinions here put forward appear to be of great importance in the study of the geographical distribution of animals, we have thought it advisable to transfer this portion of Mr. Dana's work to our pages; but the tables of facts on which they are founded would occupy too much space; they will be found in Silliman's Journal, vols. xvi. xviii. xix. & xx. —EDS.]

THE origin of the existing distribution of species in this department of zoology deserves attentive consideration. Two great causes are admitted by all, and the important question is, how far the influence of each has extended. The first is, *original local creations*; the second, *migration*.

Under the first head, we may refer much that we have already

said on the influence of temperature, and the restriction of species to particular temperature regions. It is not doubted that the species have been created in regions for which they are especially fitted; that their fitness for these regions involves an adaptation of structure thereto, and upon this adaptation, their characteristics as species depend. These characteristics are of no climatal origin. They are the impress of the Creator's hand, when the species had their first existence in those regions calculated to respond to their necessities.

The following questions come under this general head:—

1. Have there been local centres of creation, from which groups of species have gone forth by migration?

2. Have genera only and not species, or have species, been repeated by creation in distinct and distant regions?

3. How closely may we recognize in climatal and other physical conditions, the predisposing cause of the existence of specific genera or species?

With regard to the *second* head, migration, we should remember, that Crustacea are almost wholly maritime or marine; that marine waters are continuous the globe around; and that no sea-shore species in zoology are better fitted than crabs for migration. They may cling to any floating log and range the seas wherever the currents drift the rude craft, while the fish of the sea-shores will only wander over their accustomed haunts. Hence it is, that among the Pacific Islands the fishes of each group of islands are mostly peculiar to the group, while the Crustacea are much more generally diffused.

A direction and also a limit to this migration exist, (1) in the currents of the ocean, and (2) in the temperature of its different regions. Through the torrid zone, the currents flow mainly *from the east* towards the west; yet they are reversed in some parts during a certain portion of the year. But this reversed current in the Pacific never reaches the American continent, and hence it could never promote migration to its shores. Again, beyond 30° or 35° of north or south latitude, the general course of the waters is *from the west*, and the currents are nearly uniform and constant. Here is a means of eastward migration in the middle and higher temperate regions. But the temperate regions in these latitudes are more numerous than in the tropics, and species might readily be wafted to uncongenial climates, which would be their destruction; in fact they could hardly escape this. Moreover, such seas are more boisterous than those nearer the equator. Again, these waters are almost entirely bare for very long distances, and not dotted closely with islands like the equatorial Pacific.

In the northern hemisphere, on the eastern coasts especially,

there are warm currents from the south and cold currents from the north. The former overlie the latter to a great extent in the summer, and may aid southern species in northward migrations. Cape Hatteras is nearly the termination of the summer line of 70° (see Maury's Chart), a temperature which belongs to the subtorrid region in winter. On the China coast, at Macao, there is a temperature of 83° in July, and in the Yellow Sea, of 78° to 80° . But such northward migrations as are thus favoured, are only for the season; the cold currents of the winter months destroy all such adventurers, except the individuals of some hardier species that belong to the seas or have a wide range in distribution. Sea-shore Crustacea are not in themselves migratory, and are thus unlike many species of fish. Even the swimming Por-tunidae are not known voluntarily to change their latitudes with the season.

The following is a brief recapitulation of the more prominent facts bearing on these points:—

1. The distribution of individuals of many species through twelve thousand miles in the torrid zone of the Oriental seas.

2. The very sparing distribution of Oriental species in Occidental seas.

3. The almost total absence of Oriental species from the west coast of America.

4. The world-wide distribution within certain latitudes of the species we have called cosmopolites.

5. The occurrence of closely allied genera at the Hawaiian Islands and in the Japan seas.

6. The occurrence of the same subtorrid species at the Hawaiian Islands and at Port Natal, South Africa, and not in the torrid zone intermediate, as *Kraussia rugulosa* and *Galene natalensis*.

7. The occurrence of identical species in the Japan seas and at Port Natal.

8. The occurrence of the same species (*Plagusia tomentosa*) in South Africa, New Zealand, and Valparaiso; and the occurrence of a second species (*Cancer Edwardsii* (?)) at New Zealand and Valparaiso.

9. The occurrence of closely allied species (as species of *Amphoroidea* and *Ozius*) in New South Wales and Chili.

10. The occurrence of the same species in the Japan seas and the Mediterranean, and of several identical genera.

11. The occurrence of a large number of identical species in the British seas and the Mediterranean; and also in these seas and about the Canary Islands.

12. The occurrence of closely allied, if not identical, species (as of *Palæmon*) in New Zealand and the British seas; and also

of certain genera that are elsewhere peculiarly British, or common only to Britain and America.

13. An identity in certain species of Eastern and Western America.

The following are the conclusions to which we are led by the facts :—

I. The migration of species from island to island through the tropical Pacific and East Indies may be a possibility; and the same species may thus reach even to Port Natal in South Africa. The currents of the oceans favour it, the temperature of the waters is congenial through all this range, and the habits of many Crustacea, although they are not voluntarily migratory, seem to admit of it. The species which actually have so wide a range are not Maioids (which are to a considerable extent deep-water species), but those of the shores; and some, as *Thalamita admete*, are swimming species.

II. The fact, that very few of the Oriental species occur in the Occidental seas, may be explained on the same ground, by the barrier which the cold waters of Cape Horn and the South Atlantic present to the passage of tropical species around the Cape westward, or to their migration along the coasts.

Moreover, the diffusion of Pacific tropical species to the Western American coast is prevented, as already observed, by the westward direction of the tropical currents, and the cold waters that bathe the greater part of this coast.

III. When we compare the seas of Southern Japan and Port Natal, and find species common to the two that are not now existing in the Indian Ocean or East Indies, we hesitate as to migration being a sufficient cause of the distribution. It may however be said, that driftings of such species westward through the Indian Ocean may have occasionally taken place, but that only those individuals that were carried during the season quite through to the *subtorrid* region of the South Indian Ocean (Port Natal, &c.), survived and reproduced; the others, if continuing to live, soon running out under the excessive heat of the intermediate equatorial regions. That they would thus run out in many instances is beyond question; but whether this view will actually account for the resemblance in species pointed out, is open to doubt.

IV. When, further, we find an identity of species between the Hawaiian Islands and Port Natal—half the circumference of the globe, or twelve thousand miles, apart—and the species, as *Galene natalensis*, not a species found in any part of the torrid region, and represented by another species only in Japan, we may well question whether we can meet the difficulty by appealing to migration. It may however be said, that we are not as yet

thoroughly acquainted with the species of the tropics, and that facts may hereafter be discovered that will favour this view. The identical species are of so peculiar a character that we deem this improbable.

V. The existence of the *Plagusia tomentosa* at the southern extremity of Africa, in New Zealand, and on the Chilian coasts, may perhaps be due to migration, and especially as it is a southern species, and each of these localities is within the sub-temperate region. We are not ready however to assert, that such journeys as this range of migration implies are possible. The oceanic currents of this region are in the right direction to carry the species eastward, except that there is no passage into this western current from Cape Horn, through the Lagulhas current, which flows the other way. It appears to be rather a violent assumption, that an individual or more of this species could reach the western current from the coast on which it might have lived; or could have survived the boisterous passage, and finally have had a safe landing on the foreign shore. The distance from New Zealand to South America is five thousand miles, and there is at present not an island between.

VI. Part of the difficulty in the way of a transfer of species between distant meridians might be overcome, if we could assume that the intermediate seas had been occupied by land or islands during any part of the recent epoch. In the case just alluded to, it is possible that such a chain of interrupted communication once existed; and this bare possibility weakens the force of the argument used above against migration. Yet as it is wholly an assumption, we cannot rely upon it for evidence that migration has actually taken place.

VII. The existence of the same species on the east and west coasts of America affords another problem, which migration cannot meet, without sinking the Isthmus of Darien or Central America, to afford a passage across. We know of no evidence whatever that this portion of the continent has been beneath the ocean during the recent epoch. An argument against such a supposition might be drawn from the very small number of species that are identical on the two sides, and the character of these species. *Libinia spinosa* occurs at Brazil and Chili, and has not been found in the West Indies. *Leptopodia sagittaria*, another Maioid, occurs at Valparaiso, the West Indies, and the Canaries.

VIII. The large number of similar species common to the Mediterranean and British seas may be due to migration, as there is a continuous line of coast and no intermediate temperature rendering such a transfer impossible; and the passage farther south to the Canaries of several of the species is not

beyond what this cause might accomplish. Still, it cannot be asserted that in all instances the distribution here is owing to migration; nor will it be admitted unless other facts throw the weight of probability on that side.

IX. But when we find the same temperate zone species occurring in distant provinces, these provinces having between them no water-communication except through the torrid or frigid zone, and offering no ground for the supposition that such a communication has existed during the recent epoch, we are led to deny the agency of voluntary or involuntary migration in producing this dissemination. An example of this, beyond all dispute, is that of the Mediterranean Sea and Japan. No water-communication for the passage of species can be imagined. An opening into the Red Sea is the only possible point of intercommunication between the two kingdoms; but this opens into the torrid zone, in no part of which are the species found. The two regions have their peculiarities and their striking resemblances; and we are forced to attribute them to original creation, and not intercommunication.

X. The resemblances found are not merely in the existence of a few identical species. There are genera common to the two seas that occur nowhere else in the Oriental kingdom, as *Latreillia*, *Ephyra*, *Sicyonia*, &c.; and species where not identical having an exceedingly close resemblance.

Now this *resemblance* in genera and species (without exact identity in the latter) is not explained by supposing a possible intercommunication. But we may reasonably account for it on the ground of a similarity in the temperature and other physical conditions of the seas; and the well-known principle of "like causes, like effects," forces itself upon the mind as fully meeting the case. Mere intercommunication could not produce the resemblance; for just this similarity of physical condition would still be necessary. And where such a similarity exists, creative power may multiply analogous species; we should almost say, *must*; for, as species are made for the circumstances in which they are to live, identical circumstances will necessarily imply identity of genera in a given class, and even of specific structure or of subgenera.

If then the similarity in the characters of these regions is the occasion of the identity of genera, and of the very close likeness in certain species (so close that an identity is sometimes strongly suspected where not admitted), we must conclude that there is a possibility of actual identity of species, through original creation. This, in fact, becomes the only admissible view, and the actually identical species between Japan and the Mediterranean are examples.

XI. When we find a like resemblance of genera and species between temperate-zone provinces in opposite hemispheres that are almost exact antipodes, as in the case of Great Britain and New Zealand, we have no choice of hypotheses left. We must appeal directly to creative agency for the peopling of the New Zealand seas as well as the British, and see, in both, like wisdom, and a like adaptedness of life to physical nature. The *Palæmon affinis* of the New Zealand seas is hardly distinguishable from the common *P. squilla* of Europe, and is one example of this resemblance. It may not be an identity; and on this account it is a still better proof of our principle, because here is no occasion to suspect migration or any other kind of transfer. It is a creation of species in these distant provinces, which are almost identical, owing to the physical resemblances of the seas; and it shows at least, that a very close approximation to identity may be consistent with Divine Wisdom.

The resemblance of the New Zealand and British seas has been remarked upon as extending also to the occurrence in both of the genera *Portunus* and *Cancer*. It is certainly a wonderful fact that New Zealand should have a closer resemblance in its Crustacea to Great Britain, its antipode, than to any other part of the world—a resemblance running parallel, as we cannot fail to observe, with its geographical form, its insular position, and its situation among the temperate regions of the ocean. Under such circumstances, there must be many other more intimate resemblances, among which we may yet distinguish the special cause which led to the planting of peculiar British genera in this antipodal land.

The close resemblance in species and genera from Britain and New Zealand, and from Japan and the Mediterranean, and the actual identity in some species among the latter, prove therefore that, as regards the species of two distant regions, identity as well as resemblance may be attributable to independent creations, these resemblances being in direct accordance with the physical resemblances of the regions. As this conclusion cannot be avoided, we are compelled in all cases to try the hypothesis of migration by considering something beside the mere possibility of its having taken place under certain assumed conditions. The possibility of independent creations is as important a consideration. After all the means of communication between distant provinces have been devised or suggested, the principle still arises, that it is in accordance with Divine Wisdom to create similar and identical species in different regions where the physical circumstances are alike; and we must determine by special and thorough investigation, whether one or the other cause was the actual origin of the distribution in each particular case. Thus it must

be with reference to the wide distribution of species in the Oriental tropics, as well as in the European temperate regions, and the temperate zone of the South Pacific and Indian Oceans.

XII. With respect to the creation of identical species in distant regions, we would again point to its direct dependence on a near identity of physical condition. Although we cannot admit that circumstances or physical forces have ever created a species (as like can only beget like, and physical force must result simply in physical force), and while we see in all nature the free act of the Divine Being, we may still believe the connexion between the calling into existence of a species and the physical circumstances surrounding it, to be as intimate nearly as cause and effect. The Creator has, in infinite skill, adapted each species to its place, and the whole into a system of admirable harmony and perfection. In His wisdom, any difference of physical condition and kind of food at hand, is sufficient to require some modification of the intimate structure of species, and this difference is expressed in the form of the body or members, so as to produce an exactness of adaptation, which we are far from fully perceiving or comprehending with our present knowledge of the relations of species to their habitats.

When therefore we find the same species in regions of unlike physical character, as, for example, in the seas of the Canaries and Great Britain—regions physically so unlike—we have strong reason for attributing the diffusion of the species to migration. The difference between the Mediterranean and Great Britain may require the same conclusion for the species common to these seas. They are so far different, that we doubt whether species *created* independently in the two could have been identical, or even have had that resemblance that exists between varieties; for this resemblance is usually of the most trivial kind, and affects only the least essential of the parts of a species.

The continental species of Crustacea from the interior of different continents are not in any case known to be identical; and it is well understood that the zoological provinces and districts of the land are of far more limited extent than those of the ocean. The physical differences of the former are far more striking than those of the latter. As we have observed elsewhere, the varieties of climate are greater; the elevation above the sea may vary widely; and numberless are the diversities of soil and its conditions, and the circumstances above and within it. Hence, as the creation of each species has had reference most intimately to each and all of these conditions, as well as to other prospective ends, an identity between distant continental regions is seldom to be found, and the characteristic groups of genera are very widely

diverse. Comparatively few genera of Insects have as wide a range as those of Crustacea; and species, with rare exceptions, have very narrow limits. Where the range of a species in this class is great, we should in general look to migration as the cause, rather than original creation; but the considerations bearing on both should be attentively studied, before either is admitted as the true explanation.

Throughout the warmer tropical oceans, a resemblance in the physical conditions of distant provinces is far more common and more exact than in the temperate zone; and hence it would seem that we cannot safely appeal to actual differences as an argument against the creation of a species in more than one place in the tropics. The species spread over the Oriental torrid zone may hence be supposed to owe their distribution to independent creations of the same species in different places, as well as to migration. Yet we may in this underrate the exactness of physical identity required in regions for independent creations of the same species. We know that for some chemical compounds, the condition of physical forces for their formation is exceedingly delicate; and much more should we infer that, when the creation of a living germ was concerned, a close exactness in the conditions would be required in order that the creation should be repeated in another place. Infinite power, it is true, may create in any place; but the creation will have reference to the forces of matter, the material employed in the creation. The few species common to the Oriental and Occidental torrid seas seem to be evidence on this point. The fact that the Oriental species have so rarely been repeated in the Occidental seas, when the conditions seem to be the same, favours the view that migration has been the main source of the diffusion in the Oriental tropics.

As we descend in the order of Invertebrates, the species are less detailed in structure, with fewer specific parts and greater simplicity of functions, and they therefore admit of a wider range of physical condition; the same argument against multiplication by independent creations in regions for the most part different, does not, therefore, so strongly hold. As we pass, on the contrary, to the highest groups in Zoology, the argument receives far greater weight; and at the same time there are capabilities of migration increasing generally in direct ratio as we ascend, which are calculated to promote the diffusion of species, and remove the necessity of independent creations.

Migration cannot therefore be set aside. It is an actual fact in nature, interfering much with the simplicity which zoological life in its diffusion would otherwise present to us. Where it ends, and where independent creations have taken place, is the great problem for our study. This question has its bearings on all departments of Zoology; but in few has migration had the

same extended influence as in that of Crustacea. Mollusks, if we except oceanic species, are no travellers, and keep mostly to narrow limits.

XIII. There is evidence, in the exceedingly small number of torrid-zone species identical in the Atlantic and Indian Oceans, that there has been no water-communication across from one to the other in the torrid zone, during the period since existing species of Crustacea were first on the globe.

XIV. As to zoological centres of diffusion for groups of species, we can point out none. Each species of Crustacea may have had its place of origin and single centre of diffusion in many and perhaps the majority of cases. But we have no reason to say that certain regions were without life, and were peopled by migration from specific centres specially selected for this end. If such centres had an existence, there is at present no means by which they may be ascertained. The particular temperature region in which a species originated may be ascertained by observing which is most favourable to its development: we should thus conclude that the *Ranina dentata*, for example, was created in the subtorrid region, and not the torrid, as it attains its largest size in the latter. By pursuing this course with reference to each species, we may find some that are especially fitted for almost every different locality. Hence we might show, as far as reason and observation can do it, that all regions have had their own special creations.

The world, throughout all its epochs in past history, has been furnished with life in accordance with the times and seasons; each species being adapted to its age, its place, and its fellow species of life.

VI.—On *Anthracosia*, a Fossil Genus of the Family Unionidæ.

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[With a Plate.]

THE lakes, rivers and estuaries of the Carboniferous period were inhabited by two groups of Bivalves; the generic characters of neither have as yet been fully described. One group includes forms having much of the external aspect of ordinary species of *Unio*; while the other comprises members possessing the outward appearance of certain aviculoid forms of *Modiola*.

But as external resemblances are not always to be depended on in determining the genus of a fossil shell, some palæontologists have gone no further, in the present case, than merely to refer the bivalves in question to the genera named; while